Rauch (J. H.)

THE SANITARY PROBLEMS OF CHICAGO,

PAST AND PRESENT.

BY

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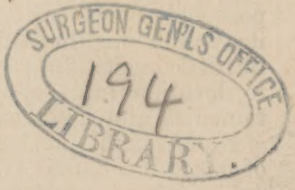

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SANITARY PROBLEMS OF CHICAGO, PAST AND PRESENT.

By the Secretary.

It is interesting to notice how little the elements of mere beauty of location, or healthfulness of surroundings, as things worthy to be considered, enter into the locating of towns which, in the usual growth of business and population, become large cities. Facilities for primitive trade and barter are the elements which generally first determine the sites of future cities. Careful selection of a site with reference to the wants of a large population, from the necessities of the case cannot be made, and in many instances where it was supposed all the conditions obtained, failures have occurred. The sanitary problems that subsequently arise unite the necessity of accepting its deficiencies in regard to water supply, to soil, to atmosphere, to location and topography, with that of applying such artificial remedies and modifications as may be appropriate and practicable.

Marsh, in his work on "Man and Nature," says: "The influence of man in changing the climate and the physical condition of a country needs no argument to substantiate it." Withdraw man, and you remove the disturber of all laws. People must be "awakened to the necessity of restoring the disturbed harmonies of nature, where well-balanced influences are so propitious to all her organic offspring; of repaying to our great mother the debt which the prodigality and thriftlessness of former generations have imposed upon their successors, thus fulfilling the command of religion and of practical wisdom, to use this world as not abusing it." He further says: "I am satisfied that we can become the architects of our own abiding place, as it is well known how the mode of our physical, moral and intellectual being is affected by the character of the home Providence has appointed, and we have fashioned for our own material habitation."

Such is undoubtedly the case, and it becomes our duty, as far as possible, to restore this harmony which is destroyed by the accumulation of human beings. The collection of many people in a small space, no matter for what purpose, is unnatural and artificial; and it is therefore necessary, in order to prevent the ill effects of such accumulations, to resort to artificial means of neutralizing the disturbing agencies.

THE NATURAL CONDITIONS—THE LOCATION AND TOPOGRAPHY OF CHICAGO.

Up to the date when this town (Chicago) was laid out, in 1833, the territory now comprised in the limits of the city and its surroundings was occupied chiefly by the Indians. The Jesuit missionaries Marquette and Joliet were attracted to the settlement at the mouth of "the creek," upon the shores of Lake Michigan, the future site of Chicago. Later we find a trading post, for barter and traffic between the Indians and venturesome and ambitious white men, who were willing to be pioneers upon the frontiers of the country, and in advance of civilization and of the government. Soon there was established a military post for the protection of the early settlers; and, indeed, it is not very many years since the last log building, composing a part of old Fort Dearborn, and located near the present Rush Street Bridge, was torn down. The fact, too, that during certain seasons of the year communication could be had in early days from Chicago, by means of boats and canoes, with the Indian villages along the Des Plaines and Illinois rivers, and thence with the settlements along the Mississippi river, was an additional feature which contributed to determine the site of the future metropolis of the Norhtwest.

When this territory was first settled, nearly the whole "divide" between the waters of the St. Lawrence and the Mississippi was frequently covered by water. Until a recent date, freshets and overflowing of large areas of territory adjacent and tributary to the early town of Chicago, were of very common occurrence.

This condition of the surrounding country can be better appreciated by bearing in mind that the original site of Chicago* was upon land lying flat and low, a level and, comparatively speaking, treeless plain, much of it marshy, and with but slight dip towards either the sluggish river or the neigboring lake. Indeed, the highest point above the level of Lake Michigan, for fifteen miles north, is only 38 feet, and southeast, for the same distance, only 23 feet.

Directly south of the city, the surface is almost level, as the highest point in sixteen miles is only 22 feet. The topography southwest is still more remarkable, as for ten miles the highest point above the level of the lake is only ten feet, at the Summit, where the waters of the St. Lawrence run northeast, and those of the Mississippi southwest. From the Summit there is a gradual descent, until the ground is lower than the surface of the lake. At twenty miles, it is only one foot above the lake.

Three miles directly west, the surface is 17 feet; five miles, 20 feet; and seven miles, 27 feet. At Austin, where, no doubt, was once the shore of the lake, and continuing two and a half miles further, to Harlem, we find an elevation of 48 feet, the highest point in any direction within ten miles of Chicago. Thence to the Des Plaines there is a descent, the bottom of the river being 26 feet; there is then a marked increase in the ascent, so that at fifteen miles the surface is 102, and at twenty, 125 feet above the level of the lake. Northwest of the city, at four miles, we find an elevation

* Chicago is situated in latitude 41° 52', longitude 78° 35', and is 591 feet above the level of the sea.

of only 10 feet; at seven miles, of 27 feet, where we again strike the original lake shore; at ten miles, 40 feet; at eleven miles, 65 feet; at twelve miles, 82 feet; from this point there is a gradual descent to the Des Plaines river, where the elevation is 33 feet; thence the ascent is gradual, and at twenty miles it is 96 feet.

It will be seen from the foregoing that the highest point within five miles from the mouth of the Chicago river, in any direction, is only 23 feet, and for ten miles 48 feet, above the level of the lake; and that a large portion of this ground was originally low and swampy, with but little surface drainage and an average elevation of about 12 feet only.

As a necessary consequence, as in all plains, great and sudden changes of moisture and temperature take place. So far as regarded its sanitary and topographical features, such was the natural condition when Chicago was located. The winds meeting with no obstructions, had full sweep. The only interruption to the winds in this open plain might be said to be the narrow belt of timber on the Des Plains river, with here and there an occasional patch of thinly covered woodland on the elevations which once were the shores of the lake. With these exceptions the open plain is continuous for a great distance northwest, west and southwest. It is true, timber is scattered north and south, but, unfortunately, there is not enough to materially influence the climate, in addition to the fact that the winds are rarely from either of these directions.

In an area of four hundred square miles surrounding Chicago, there were only about twenty-five square miles which were thinly covered with timber; ten of these were found on the north side of the city and along the north branch of the Chicago River; five south and southeast; and ten on the ridges six miles west, and in the valley of the Des Plaines river.

THE GEOLOGY OF THE SITE OF THE CITY.

The geological structure of the region embracing Chicago and the surrounding country is exceedingly simple.

The underlying rock is the Niagra limestone, which has a general dip N. N. E., and consequently sinks deeper as traced lakeward.

Upon this floor was originally deposited a mass of blue clay, not less than 100 feet in thickness; but as traced towards the former rim of the lake, it rapidly thins out.

This rim is clearly defined in one or more terraces which are traceable from the head of the lake far into Indiana. To the west of the city, however, eight and a half miles distant, at Harlem, they constitute the "divide" between the waters of Lake Michigan and the Mississippi.

While the Lake has receded far below its former level, it has left behind a series of sand ridges, the intervals between which were occupied by ponds, which by reason of the sluggish flow of the water and their sheltered position, have proved favorable to the growth of the peat-producing plants, from whose decay have resulted large accumulations of humus, or vegetable matter. It is upon this ancient lake-bed that Chicago was founded.

The original surface was diversified by sand-banks, most numerous along the lake shore, extending occasionally to the depth of sixteen feet, by partly filled lagoons, and by a vegetable mold (which covers the greater portion of the city), resting sometimes on blue clay, and sometimes on beds of sand and gravel, and occasionally mixed; the depth of these varying with their proximity to the Chicago river and its branches. The whole region, as before remarked, was originally low, flat, and ill-drained. Some of the business blocks at the present time are built upon partly filled lagoons. In the soundings made, preparatory to the construction of the lake tunnel for the water works, it was found that the lake-bed was composed of blue clay, with superficial sands above, which shifted in heavy storms. Such a soil must necessarily exercise a decided influence upon the health of those living upon it, depending, of course, upon the question whether their houses rest upon sand, clay, or humus.

THE INFLUENCE OF LAKE MICHIGAN ON HUMAN LIFE.

Of all the local conditions that obtain at Chicago, none exercise a greater influence on the climate than Lake Michigan. It moderates the extreme cold of winter and the oppressive heat of summer, increases the humidity of the atmosphere and the quantity of rain that falls, and causes local currents of air, thus partially changing the prevailing winds of this latitude, producing necessarily local changes of temperature. These local undulations are most marked in the spring, owing to the fact that the specific heat of the land is only one quarter that of the water, and is both absorbed and given out more rapidly; while water, on the other hand, absorbs it more slowly, stores up a greater quantity and parts with it slowly, owing, no doubt, to the difference in their conducting and radiating properties. It is mainly due to this fact that our springs are so cold, raw, and long continued; that is, the water is not as soon heated as the land, thus giving rise to local changes of temperature and of winds. In the autumn the heat of the water is less readily abstracted than that of the land, thus causing the temperature in the immediate vicinity of the lake to be milder than even at localities further south and west. The mean temperature of the lake is no doubt the same as that of the land for the year, differing only in the absorbing and parting power of heat, as is evidenced by the fact that the freezing point obtains only a short distance from the shore. It will therefore be seen how, for eight months of the year, and sometimes even for nine, the lake exercises a wholesome influence upon health, counteracting, to some extent, the great and sudden changes incident to our level and open topography, while, during the remaining months, it is injurious to health, on account of the cold and chilling effect it has, in addition to causing sudden changes. Its agency in purifying the atmosphere by absorption it is hardly necessary to dilate upon in this connection.

THE INFLUENCE OF THE WINDS.

We come now to consider the winds. They are the result of changes of temperature and the precipitation of moisture, acting as changes of density, and as the movements of bodies would act to produce currents and movements in a mass of water.

The free movement of air in summer, in certain localities, is beneficial in dissipating noxious emanations and purifying the atmosphere, while in the same locality, in the cold season, it abstracts heat, in proportion, of course, to its velocity and humidity, and thus often acts injuriously upon life. The seeds of disease are frequently wafted by winds from unhealthy localities, and thus endanger those who live quite remote from the local cause itself.

Fevers and acute pulmonary and inflammatory diseases do not usually manifest themselves under the influence of the same wind, although fever and certain other diseases may occur in connection with any currents which waft the air from the neighboring surfaces, where the elaboration of a morbific cause is going on.

The north wind, which is less frequent than any other, generally exercises a beneficial influence, and in winter is the mildest, with the exception of the southeast and east winds. This wind, like all others, is influenced by locality in its effects upon health.

The northeast wind of March, April, and May, is cold and moist. This wind increases pulmonary, rheumatic and inflammatory diseases in the spring months; but during the summer months, when the heat is extreme, or in winter, when very cold, it is beneficial and salutary.

The east wind, with the exception of the north, is the least frequent, and is more common in the spring than at any other season of the year. In the winter it is warm, and when it prevails there is a diminution in the number of cases of acute inflammatory disease. The lake exercises a marked influence upon this wind and that from the northeast.

Of all the winds, none is so depressing and enervating as the southeast wind. It is oppressive to man and beast, in consequence of checking evaporation, thus raising the temperature of the body, and causing the lungs to exhale a larger amount of carbonic acid than usual, and in this way exhausting the vital energies. The topography of the country south and southeast of the city is such as to promote currents of air from this direction, and to direct them toward the city. When the weather has been intensely cold for a number of days, a change to the southeast wind will diminish the mortality, but for at least nine months in the year it is the most fatal wind that we have in Chicago. The south wind is more common than either the east or the north wind. In winter, the south wind exercises a beneficial influence in moderating the extreme cold of the westerly winds, diminishing the mortality, and the same result is observable in the spring.

The prevailing wind, not alone of Chicago, but of the greater portion of the valley of the Mississippi, is the southwest wind; if long continued, it produces harshness and dryness of the skin and general malaise. It partakes of the character of the country, and of the seasons. This wind, sweeping over a greater unbroken expanse than any other, necessarily exercises a great influence upon health, in

addition to its wafting the malarious exhalations of Mud Lake and the region contiguous to the Illinois and Michigan canal over every portion of our city, and, next to the southeast, is the most fatal, and causes the greatest mortality. There are years in which this is the hottest wind, and, again, it is the coldest.

The west wind is more common than any from the direct points of the compass; is most frequent in winter, when it is the coldest and driest. The greatest mortality, when this wind prevails in winter, is by acute inflammatory diseases. In the summer, its influence is marked by a great diminution in the number of deaths. It may be said to be the healthiest wind during the entire year.

The northwest wind is cold, keen and penetrating in winter; in the spring, cold, blear and bleak; and, in summer, cool and refreshing. It is of about equal frequency during the winter, spring and autumn months, being least prevalent in summer. Its injurious effects are strongly marked in winter, and particularly in the spring, when it causes great changes of temperature, resulting in pulmonary, rheumatic, neuralgic, and inflammatory affections; while in summer it diminishes the rate of mortality, and exercises a wholesome influence upon the general health.

THE TEMPERATURE.

Owing to the open and treeless plain upon which it is located, and by which it is surrounded, the consequent exposure to the winds, and the evaporation from the lake, Chicago is subject to very frequent and sudden changes of temperature. From observations made at Fort Dearborn, extending from 1832 to 1836, the annual mean temperature was 46.7° F., and from 1866 including 1876, 49.5° F., which shows that the temperature is gradually becoming higher.* As a rule, January is the coldest month, February and December are next; while July is the hottest, and August and June are next so. The extremes of temperature are not as great here as they are farther west, and at points remote from large bodies of water. The climate may be said to be semi-continental. By way of comparison with other localities, it has been found, from observations made for a series of years, that the range of temperature at St. Louis is 125° F.; at Prairie du Chien, 132°; at Rock Island, 120°; Fort Snelling, 140°; Council Bluffs, 129°; Detroit, 107°; Toledo, 103°; Lansing, Mich., 107°; Mackinaw, 117°; and Chicago, from 1832 to 1836, 116°, and from 1866 to 1870, inclusive, 111°. Since the latter period it has come down to 107°, showing that the climate is becoming more equable, and that the alternations of heat and cold are not as great as when the place was first settled.

THE RAIN-FALL.

The amount of rain that falls is an important factor in the healthfulness of a locality, especially in one like that of Chicago. Here, as elsewhere, there are annual fluctuations of mortality, independent of epidemics.

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* For 1877, 50.3°; for 1878, 51.8°.

The months of July, August and September are those in which the lack of drainage has been most marked in its influence upon human life, especially in cases of children under five years of age. The following table will show that the death-rate has tallied with the rain-fall during these months from the year 1866 to 1872, inclusive:

Year.	July, inches.	August, inches.	Sept., inches.	Total 3 mos., inches.	Total year, inches.	Death-rate per 1,000.
1866	3.58	7.84	6.53	17.95	36.65	32.22
1867	1.51	2.32	.40	4.23	21.26	21.16
1868	3.86	3.58	7.08	14.52	37.33	23.74
1869	3.21	1.38	.89	5.48	31.66	23.16
1870	3.71	2.17	2.82	8.70	23.62	24.53
1871	2.56	.50	.10	3.16	32.85	21.46
1872	4.05	2.56	6.43	13.04	28.94	27.61

The mean annual rain-fall at Milwaukee for twenty-five years was 30.20 inches; at Toledo for six years, 38.94; at Lansing for four years, 30.56; and at Chicago from 1866 to 1874, inclusive, 30.84 inches.

I have also observed that there were greater annual fluctuations at Chicago than at the other points mentioned, all being within the thirty-inch rain-belt. The difference is also greater in the summer. Since 1874 there has been a marked increase in the number of inches that fell at Chicago, so that for the last five years, including 1879, we have had 39.87 inches.* Attention is called to the following table, showing the chief causes of death for the year 1872, nearly all the decedents being under five years, and showing how the rain-fall and temperature affect infantile life. Nearly one-half of all the deaths during this period resulted from the six mentioned diseases:

	April.	May.	June.	July.	Aug.	Sept.	Total.
Cholera infantum	6	10	146	549	530	187	1,428
Convulsions	94	71	101	112	116	81	573
Diarrhœa	8	5	53	73	132	63	384
Dysentery	2	3	26	38	63	30	162
Tabes mesenterica	8	14	21	40	38	27	148
Teething	3	14	16	25	34	14	106
Total	121	117	363	837	913	402	2,801
Mean daily temperature, degrees	48.6	57.5	70.2	72.5	72.	94.	.....
Rail-fall	2.99	3.28	3.41	4.08	2.56	6.43	.....

THE ARTIFICIAL CONDITIONS.

I have thus far described the natural conditions surrounding Chicago, and will now briefly call your attention to what has been done to improve its sanitary condition. The question of the water supply first attracted attention, as will be seen by the following:

*In 1878 48.84 inches fell, a greater amount than has fallen in any year since 1832. The extreme fluctuation during the period covered in the above is 27.58 inches: only 21.26 inches in 1867, and 48.84 inches in 1878, a difference of considerably more than double.

THE WATER SUPPLY OF THE CITY.

During the prevalence of cholera in 1849 and 1850, it was observed that nearly all who drunk the water of a certain well on North LaSalle street, died. This, of course, attracted attention, and was supposed to be owing to the fact that the well received the drainage from privies in the neighborhood, and in this way infected those who drunk the water. This was true; but I found afterward that in this neighborhood the soil was stratified by thin layers of blue clay, which is impervious to water, and whenever these layers were penetrated by wells they acted as drains for a great area, the remaining portion of the soil being composed of sand until the thick stratum of blue clay underlying the greater portion of the city was reached. My attention was first called to this fact in the City Cemetery, while I was investigating the subject of intramural interments, in 1859. I here found in certain portions of the ground, particularly that adjoining Clark street, and supposed to be the highest and best for burial purposes, at a depth of about two and a half feet, a stratum of blue clay about six inches thick, the overlying stratum being composed mostly of humus and of sand. The blue clay penetrated, sand was again found to the depth of five feet, the required depth of graves in this cemetery. After a heavy rain-fall, water had to be dipped out of the grave while the digging was in process. I also noticed, in a number of instances, that when the graves were finished but little water was found in them, while in the course of an hour or two they were filled to the upper edge of the blue clay. In one case, in a space where no graves had been dug before, I saw the water running through into the opening after the blue clay was cut.

The effect of drinking well-water was so marked during the prevalence of cholera in the years mentioned, compared with that of drinking lake water, which was supplied to a small number of inhabitants by the Chicago Hydraulic Company, a private enterprise, that an act was passed, on February 15, 1851, by the Legislature of Illinois, incorporating the Chicago City Hydraulic Company. This was the commencement of our present magnificent system of water supply, which has grown with our needs and necessities; and it is not presumptuous to say that at this time the supply of water is as great and good as that of any large city in the world.

THE DRAINAGE OF THE CITY.

The necessity of the systematic drainage of Chicago was not fully appreciated until it had suffered from epidemics for six years in succession, five of cholera and one of dysentery; the death-rate during this period being higher than that of any other city in the United States. As the result of this terrible experience, on February 14, 1855, an act was passed by the Legislature of Illinois creating the Board of Sewerage Commissioners. In compliance with the act, the commissioners were elected as prescribed, and steps immediately taken to give practical effect to the same in surveys, and in the consideration of plans for the drainage of the city. The plan proposed by E. S. Chesbrough, Esq., was adopted in December, and in 1856 the work of constructing sewers commenced. This

has been mainly adhered to since, and prosecuted with varying vigor and effect, as will be seen by the following table, showing the number of feet built annually, the population, the mortality, and the death-rate per thousand:

Sewerage.

Year.	Number of feet of sewer built.	Population.	Deaths.	Death-rate per 1,000.
1856	31,794	84,113	2,086	24.80
1857	25,681	93,000	2,414	25.66
1858	101,879	84,000	2,255	26.84
1859	55,208	96,000	2,008	21.36
1860	69,024	109,260	2,264	20.70
1861	2,826	120,000	2,279	18.99
1862	15,685	137,030	2,835	20.69
1863	39,605	150,000	3,875	25 83
1864	25,021	161,288	4,448	27.57
1865	29,948	178,492	4,029	22.57
1866	48,127	200,418	6,524	32.22
1867	89,661	225,000	4,648	21.17
1868	47,841	252,000	5,984	23.74
1869	139,705	280,000	6,488	23.16
1870	78,166	299,227	7,343	24.53
1871	50,392	325,000	6,976	21.46
1872	57,342	367,293	10,156	27.60
1873	47,342	385,000	9,557	24.82
1874	146,702	395,409	8,025	20.29
1875	222,322	405,000	7,899	19.50
1876	120,971	415,000	8,573	20.65
1877	64,666	434,000	8,026	18.03
1878	88,031	450,000	7,422	16.49
1879	145,381	475,000	8,614	18.21

For the purpose of more clearly showing the influence upon life of this, the most important sanitary movement ever inaugurated in this city, I would call attention to the fact that the mean annual death-rate from 1843 to 1856* was 37.91 per thousand, while from 1856† to 1870 it was only 23.97, from 1870 to 1879 inclusive 21.15. The last period includes the effect upon life of the "great fire," and also of an epidemic of scarlet fever.

The following will more fully explain how drainage acts beneficially in this city:

I have found, in judging of the comparative healthfulness of different wards, that the soil affects health by its conformation, elevation, and mechanical structure—conditions which influence absorption and radiation of heat, reflection of light, absorption, retention and movement of water over and through it, in addition to the passage of air through the soil. The soil may also affect health by its chemical character, which acts especially by altering the composition of the air over, or the water running through it. In this way, in addition to its natural character, the decomposition of organic matter affects the atmosphere or the water, and this is particularly the case when houses are located upon the ground, where, owing to the influence of temperature and moisture, septic gases are generated and pent up, and thus exercise an injurious effect upon the occupants of such towns. It is therefore a matter of great importance

*This is still more marked when it is borne in mind that up to this date there was a great excess of adults, as is always the case in a newly settled country or town.

†The year when sewer construction commenced.

to keep the ground under buildings as dry as possible, to prevent the formation of noxious gases, particularly where the sun and air have no direct influence.*

In Chicago this can be accomplished only by thorough surface and subsoil drainage.

"The heat of the sun is absorbed in different amounts by different soils equally shielded. Color and aggregation seem chiefly to determine it. Loose and incoherent sands are the hottest, while compact and clayey soils are the coldest. The absorbing and radiating powers of soils are not necessarily equal, though they may be so. Generally, the radiating power is more rapid than the absorbing,—soils cool more rapidly than they heat. Here the sandy soil is the most healthy, while the clayey soils are damp and moist, and naturally productive of certain classes of disease.

"It has also been observed that some soils absorb and retain moisture more than others. Sand absorbs and retains but little water, clays from ten to twenty times more, and humus, or common surface soil, more than fifty times as much as sand.†

"Clays sometimes contain as much as ten per cent. of water by weight, and thus are injurious to health in two ways—by being moist, and, although they contain but little organic matter, the moisture aids in its decomposition, and thus they are malarious."‡

In any depression into which there is drainage, no matter what the character of the soil, there is danger to health. Even sandy soil may be damp from this cause, the water rising through the loose particles from the pressure of higher levels; or, as is frequently the case in this city, there are pockets of sand into which the drainage of the surrounding soil collects; or an impervious clay is found forming a basin without an outlet, where the water collects and remains until removed by drainage or evaporation.

In July and August, 1849, cholera was epidemic in this city, and generally prevailed in low and filthy localities. This did not obtain, however, in one instance, as in three blocks, not far from where the Water Works are now located, in the locality known as the "Sands," which was high, sandy and apparently dry and salubrious, it was very severe and fatal. This locality was inhabited by 322 persons, who were chiefly Norwegians, many of whom had recently arrived.

Nearly all were attacked, and forty-four fell victims to the malady. At the time, and for many years after, it was queried as to the cause, since the locality was regarded as, comparatively speaking, a healthful one. It was not until 1869 that the chief factor in this high death-rate was discovered by myself. While engaged in examining the borings made in different parts of the city, I found that

*At one time it was customary in Chicago to build the smaller houses directly on the ground; but the custom is gradually disappearing, because the death-rate was found to be higher where the tenement was so built than where it was elevated or had a basement.

†In the winter of 1870 and 1871 I went to South America, at the request of the Orinoco Mining and Exploring Company, to see whether the sanitary condition of a gold-mining district in Venezuela, south of the Orinoco, could be improved. By carefully weighing and drying the soils, I found that they contained even more moisture than is indicated in the text.

‡From my report on Drainage, to Chicago Board of Health, 1868.

there was a depression, or basin, in this locality, in the blue clay, and, as a necessary consequence, the drainage of the neighborhood collected to the depth of two and three feet, while the drainage elsewhere found its way to the lake and the Chicago river. This basin was about seventeen feet from the surface, the overlying strata being composed of loose sand. As these people used lake-water for culinary and domestic purposes, the prevalence of the disease was regarded the more remarkable. No doubt the privies drained into this basin, and the excreta from the first cases was soon carried into it, with the foregoing result. They were living, as it were, above a hidden cesspool. The locality, since sewers have been built, is one of the healthiest in the city.

In July, 1873, during the prevalence of what was called cholera in the southern portion of this city, I noticed a most marked effect of drainage. The district in which the disease prevailed was densely populated by Germans, Swedes and Poles, with a level, sandy soil, and but little surface drainage. The water was obtained from shallow wells, supplied with surface-water, ordinarily from five to sixteen feet in depth, and, to protect them from caving in, they were lined with plank. A careful inspection of the block in which the first cases occurred, satisfied Dr. Reid, the health officer, and myself, that the water supply had something to do with the malady, being satisfied that the privies and the drainage of a number of cow-stables went into the wells. Steps were immediately taken to supply the locality with lake water, and the wells were all fouled, so that the water could not be used for domestic or culinary purposes. After these precautions had been taken, no new cases occurred for three weeks.

The block fronting on the east side of Butterfield street, north of Thirty-eighth street, was perfectly level, and had really no surface drainage; while the block south of Thirty-eighth street, and on the same side of the street, in population and other conditions, was about the same, with the exception of a little better surface drainage, and a ditch of two feet in depth on two sides of it. The number of deaths north of the street, and where the disease first made its appearance, was eleven, and south, only two. I happened to be there on July 5, during a heavy rain-fall, and observed that the surface on the north side was covered with water, while on the south the ditch had carried it nearly all away. To my astonishment, in half an hour the water had entirely disappeared on the north side, and the water in the wells had risen nearly two feet, while on the south side but little change had taken place in the depth of the water in the wells.

I had frequently been impressed with our great infantile mortality, but having made a study of this question early in 1873, I came to the conclusion that this mortality was greater in this than in any other large city in the United States. In judging of this question, it must, however, be borne in mind, that we have a younger and more vigorous population than any other city, and that, proportionately, we have more children and fewer deaths of those over fifty years of age. Since 1856, there were only two years—1866 (when cholera was epidemic) and 1870—that the number of deaths under

five years was greater than all others.* This great infantile death-rate is most marked in the undrained districts.

In my report to the Board of Health of this city, in April, 1873, occurs the following:

"The increase in the number of deaths in 1872 over 1871 was 3,180, a greater change than has occurred in any two years in the history of the city, no matter what the increase of population was, or whether the city was visited by cholera or any other malignant epidemic. This was the more noticeable from the fact that there was not a marked epidemic prevalent, although small-pox and cerebro-spinal meningitis existed in the city, but the number of deaths from these and similar diseases was not great enough to cause this change.

"Attention has already been called to the effect of rain-fall on life, and, after careful investigation, I can come to no other conclusion than that if our system of sewerage had been extended with the same rapidity that it was from 1866 to 1870, this great increase of mortality would not have occurred.

"Prepare tables and group data as we may, the same general facts meet us. This is the more noticeable when it is borne in mind that we know positively how many feet of sewers have been constructed, and how many deaths occurred in each ward, but we do not know with absolute certainty what the population was in each year, as in some years it was only estimated, and in 1872 obtained from the school census. With these uncertainties, and making due allowance for all errors, the result is still the same. For the first period of sewer construction ending in 1860, there were built 2.59 feet to one of the population; the next, ending in 1866, there was a falling off to 2.23 feet, and from 1866 to 1870 inclusive, there was an increase to 2.67 feet, and in 1871 a decrease to 2.54, and in 1872 a still greater decrease to 2.43 feet. It will, therefore, be seen that for the last two years the population of the city has been increasing faster than the sewerage has been extended, and that this is the chief cause of the increase in the death-rate. Allowing 1,200 of the deaths for increase of population, and the direct result of the fire, 655 that died of small-pox, 425 from crowding and the indirect effects of the fire, we still have an increase of 900, which I am satisfied was caused by the want of proper drainage.

"A comparison of the Eighteenth and Fifteenth Wards will demonstrate the truth of the position taken in regard to sewerage. The first-mentioned ward has nearly three feet of sewerage to every inhabitant, while the other has but seven-eighths of a foot to each one of the population. What natural advantages there are, such as elevation, etc., are in favor of the Fifteenth Ward.

"The number of deaths for July, August, and September, of 1872, were 1 in 104 in the Eighteenth Ward, and 1 in 65 in the Fifteenth; and for the whole year, 1 in 56.70 in the Eighteenth, and 1 in 27.02 in the Fifteenth. Of those under 6 years, we find in the Eighteenth Ward 1 in 14.35, while in the Fifteenth there was 1 in 7.81.

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*In 1878 the death rate was lower than ever before, and this decrease is manifest in the act that there were 1,445 more deaths of those abo ve five years than under.

"In the Eighteenth Ward there are only 89 square yards to each inhabitant, while in the Fifteenth there are 374; but, taking an extent of territory equal to the area of the Eighteenth, from the lower and eastern portion of the Fifteenth, where the greatest mortality occurs, the difference is not so great, while the air space is still greater than in the Eighteenth Ward. The density of the population in the Eighteenth Ward has been increased since the fire, by the building of a number of houses by the Relief and Aid Society, on lots on Hawthorne avenue and Elm street, and two and three deep on the same lot, and in a portion of the ward that is undrained. In addition, almost every portion of this ward was burned over, so that the privation, added to the depressing effects of the fire, no doubt had some influence in increasing the death-rate.

"The Eighteenth Ward, as a whole, was naturally lower than any other in the city, until sewers were constructed and the streets improved. These wards are selected for the purpose of comparison, because they are more nearly alike than any two in the city, and lie on the North branch, directly opposite to each other. Taking all things into consideration, the Eighteenth is the poorest ward in the city. Every portion of the ground is clayey, and was originally low, and its inhabitants are nearly all of the poorer class of our foreign population, of different nationalities, as is also the case in the Fifteenth Ward, with the exception that there are more Irish in the Eighteenth than in the Fifteenth."

The report to the Board had the desired effect, for, by reference to the table on sewerage (page 102), it will be observed that from 1873 to 1877 there was a large increase in the construction of sewers. Until this period, the annual increase of sewerage did not keep pace with the annual increase of population, but during this period it really overtook it, and there was a corresponding decrease in the death-rate, and although in 1875, 1876 and 1877 we had an epidemic of scarletina, yet the death-rate steadily decreased.

THE PUBLIC PARKS.

It was not until 1866 that the people of Chicago began to take decided steps towards creating public parks on a scale commensurate with the prospective greatness of the city. Several squares and plats of ground had been devoted to the public for breathing purposes in the original plat, when the town was first laid out, and in subsequent additions made to the city.* Nothing tangible, however, was really accomplished until in 1869, when, by acts of the Legislature, the North, South, and West Chicago parks were created.

The two South Parks contain about 900 acres. There are three parks on the West Side—the Douglas, the Central, and the Humboldt parks—which contain in all 670 acres, and which are connected by boulevards nearly four miles in length. Lincoln Park contains 310 acres, and is located on the Lake Shore, in the north part of the city. All these parks will be connected by wide boule-

* In 1859 I recommended that the Public Cemetery be converted into a public park. This cemetery now forms the greater portion of Lincoln Park.

vards, which are already half built, thus encircling the city by a magnificent driveway twenty-four miles long. The parks proper and the boulevards contain nearly 2,500 acres, and when complete will make as beautiful a park system as there is in the world, and one which is the best arranged from a purely sanitary standpoint.

In the year 1868 I had the honor to be requested by the Chicago Academy of Sciences to prepare a paper on this subject. My report made to that body was entitled "Public Parks: their Effects upon the Moral, Physical, and Sanitary Condition of the Inhabitants of large Cities, with special reference to the City of Chicago," and was published the following year.

In this essay, after giving an account of the parks in all the large cities of this country and of Europe, I discussed the physiology of vegetation, and of tree-growth, in their relations to climate and health. My main object was to show how, by the proper location of parks and improvement, and the planting of trees, the various disadvantages of our location could be overcome by artificial means. It must be borne in mind that, on the South and West Sides especially, these parks were located on marshy grounds, which in the spring were liable to overflow, and in the summer and autumn to give off miasmatic exhalations. The improvement of these grounds necessitated their drainage, which brought the environs of the city under a healthful condition. It also afforded a place of deposit for manure and other offal that could be utilized, thus materially assisting in keeping the city proper in a good sanitary condition. Besides, it stimulated and encouraged the improvement and adornment of the adjacent property to a very large extent.

Within the last ten years at least *one million* of trees have been planted in the parks, along the boulevards, on private grounds and the suburbs, within twelve miles of the City Hall.

The experience of the city of Chicago in the matter of these parks has fully verified the predictions made in the paper referred to. I said "that it is not presuming too much to say that the climate of Chicago may be materially modified, and rendered more equable, by the proper location of parks, and the planting of trees, thereby diminishing the mortality of preventable diseases, and improving the general health."

From a careful examination of the meteorological record it will be seen that the drainage of the city, and of the outside lands, and this extensive tree-planting, have already diminished the climate extremes incident to our peculiar location. It is also quite certain, as the trees become larger and others are planted, these results will be more apparent and more beneficial to the inhabitants.

In the same paper I also said: "We, perhaps more than any other community, need all the possible safeguards against overwork to be thrown around us, and I know of no better way than by the creation of parks, that will be an ornament to the city, and places of resort, where all may enjoy themselves in a rational and healthful manner. We need parks to induce out-door exercise, and for the pleasant influences connected with them, which are so beneficial to our overworked business men, to dyspeptics, to those afflicted with nervous diseases, and particularly to the consumptive,"

I introduce these quotations simply to show that sanitary science has made sufficient progress at the present time to admit of the supreme test which science falsely so-called can never endure—that of verification by subsequent experience; and in this connection I will venture to make one additional quotation from my report to the Chicago Board of Health, on Drainage, made in 1869, in which I said:

"From the results of drainage and other sanitary measures carried on in this city, it may be inferred that the judicious expenditure of money for sanitary purposes is a sound maxim of municipal economy, and from past experience I am satisfied that the mean annual death-rate can be reduced to 17 per 1,000 by continuing in force the present sanitary and drainage regulations, thereby making Chicago one of the healthiest cities in the world."

POLLUTION OF STREAMS.

As a contribution to the history of the efforts of the Board in its study of this subject, the following report upon the Chicago river and its agency in affecting the waters of the Des Plaines and Illinois rivers, is submitted in this connection, since it forms one of the most important of the present sanitary problems of Chicago:

To the Illinois State Board of Health:

GENTLEMEN:—In pursuance of your instructions, and in the sanitary interests of the State, I have devoted all the spare time that I could to the consideration of the pollution of streams, and especially to the effect of the Chicago sewage on the Illinois river.

The following report, which is submitted at this time because immediate action is necessary, contains the substance of my investigations and the conclusions arrived at thus far; but it is only preliminary to a more comprehensive one which I design to submit to you at a future time.

The factors connected with the drainage of Chicago, through the Illinois and Michigan canal, are many and of a diversified character. To accurately determine the relative effect of each, as meteorological changes occur during the year, requires the closest study, and involves much labor. The importance of the subject cannot be overestimated, for it involves the sanitary well-being and comfort of at least one-third of the population of the State. I have also conducted similar investigations with regard to the pollution of the Sangamon river, from which the water supply of the city of Springfield is obtained, and the Cahokia creek, at East St. Louis.

A SKETCH OF EFFORTS MADE TO CLEANSE THE CHICAGO RIVER.

From the earliest days in the history of Chicago, the Chicago river has attracted anxious observation from a sanitary standpoint, and the anxiety has increased with the increased population of the city and the suburbs, especially since the river has been the receptacle of a large part of the sewage. When a more perfect system of sewerage became imperatively necessary for the health of

the city, the widening and deepening of the Illinois and Michigan canal to the capacity of a ship canal was suggested as a means of at once facilitating the commerce of the city and lakes and purifying the river. The one was urged as a proper national enterprise, and the other as a vital necessity for the increasing population of the locality. In July, 1860, the Sewerage Commissioners of Chicago recommended that the canal be enlarged and deepened so as to create a constant current from Lake Michigan into the Illinois river, but their suggestion was not deemed necessary at that time. The pollution of the river increased, however, beyond all expectation, not only by reason of the increase of population, but from other causes. Among the latter was the increase in the slaughtering of hogs and cattle and the packing of meats. In the year 1860, 306,428 head of cattle and hogs were killed and packed, and all of the offal was passed into the sluggish river. In 1863 this business had increased enormously. In that year the number of cattle and hogs slaughtered increased to 1,029,948, and the offal was still swept into the river. There has been a vast increase, year by year, in this business ever since, keeping pace with, or even exceeding, the increasing volume of sewage produced by the rapidly growing population. This accumulation of sewage was partially relieved by pumping-works at the head of the canal; but the relief so afforded could not keep pace with the increase of sewage and offal, and in 1863 a remarkable epidemic of erysipelas occurred, which prevailed exclusively in close proximity to the South branch and to the main river. The great amount of animal refuse thrown into the South branch was supposed to have been the cause of this epidemic. The pollution of the river from these causes increased daily, in 1863 and 1864, and on January 9, 1865, a commission of engineers was appointed "to devise the best plan to cleanse the Chicago river."

This Commission presented their report on March 6 of that year, and, after discussing several projects, recommended that, "in view of the facts in the case, the best plan to cleanse Chicago river that we can devise is to cut down the summit of the canal so as to draw a sufficient quantity of water through it from the lake to create the necessary current in said river." It was urged as an argument in favor of the proposition, "that the money expended in cutting down the summit of the present canal will constitute a part of the expense of enlarging the present canal so as to admit the passage of steamboats of the largest class, an improvement which must soon be made." This plan was adopted, and, in the fall of 1865, the work of deepening the canal was commenced. It was completed in 1871, and, in July of that year, water was admitted at the deep cut from the river. The cut so made at the head of the canal was six feet, and it was computed that at an ordinary stage of water twenty-four thousand cubic feet per minute would flow from the river into the canal.

EFFECTS OF PUMPING THE RIVER INTO THE CANAL.

From the year 1860 to 1865 the pumps at Bridgeport were only used to supply to the canal such water as was needed for navigation; and their action in purifying the river, though marked and valuable, was only incidental. But in the latter year the Board of

Public Works made an arrangement with the Canal Commissioners to utilize the pumping-works as much as possible for the cleansing of the river. It happened, however, in that year that unusual rains kept the river in fairly good condition without this extra use of the pumps. But the arrangement was maintained, and, in 1876, the pumping-works were in operation for sixty-two days; in 1867 they operated one hundred and fifty days; in 1868, seventy-three days; and, in 1869, one hundred days. The amount of water raised eight feet by them in 1869 is estimated at ten thousand cubic feet per minute. The effect of their operation was marked and favorable, but the result was affected by the operation of other causes, which at times aided and at others hindered the purification of the river. These causes were the variations in the lake level, the local rains, and, especially, the constant increase of sewage and offal resulting from the increasing population, and the slaughtering and other business interests.* These influences were constantly operating, and it was found necessary to increase the use of the pumps each year, as is shown in the figures stated above, whenever possible, owing to the limited capacity of the canal, which also depended upon the rainfall. As the population increased, and, necessarily, the amount of sewage, also, the effect of the pumps in cleaning the river was less marked.

After the water was let into the "deep cut," in 1871," it purified the South branch and the main river; but it was soon discovered that it effected no marked change in the water of the North branch. The latter continued to be so foul that in 1873 the Fullerton avenue conduit was begun, with a view to its purification. About the time the deepening of the canal was completed, the slaughtering business was transferred to the stock-yards, where the drainage is into the south fork of the South branch, and it was soon apparent that the drainage afforded by the "deep cut" and the canal had but little influence in carrying off the drainage of these establishments, though, owing to local and transitory causes, the water in the south fork was occasionally cleansed.

CAUSES WHICH AFFECT THE FLOW OF WATER FROM THE LAKE INTO THE CANAL.

The drainage of the Chicago river into the canal is influenced by several causes which may temporarily aid or retard the carrying off of the sewage. Among these is the elevation of the lake level, the extreme fluctuation of which may be stated, as a general rule, at about three feet. As a means of arriving approximately at this point, I have procured careful measurements, showing the average annual depth of water at the head of the canal since and during 1871, in feet and decimals. These measurements were made three

* It is gratifying to be able to here note that, notwithstanding the enormous increase of the slaughtering business in Chicago within the past few years, the nuisances incident to rendering and utilization of offal have been diminished.

times daily at the old lock at Bridgeport, and the mean for each day carefully noted. The annual average depths are as follows:

1871	8.60	1876	9.57
1872	7.81	1877	9.24
1873	8.25	1878	8.88
1874	8.50	1879	8.11
1875	8.23		

The average for nine years is 8.62.*

For these measurements and figures I am indebted to Mr. William Thomas, general superintendent of the canal.

Of course there are fluctuations in each year that do not appear in the figures which exhibit the average. The lake is always highest in July and August, and lowest in December and January. In addition to and quite independent of the annual fluctuations of the lake level, there is a periodic rise and fall covering a series of years, the cause of which must be sought among the influences which

*Since the Report was written, the following statement of average water gauges at Bridgeport, from August, 1871, to October, 1879, showing the average for each month and year, and for the whole time, and the highest and lowest stage for each month, year and for the whole time, was prepared by Mr. Jenne:

Year.	January	February	March	April	May	June	July	August	September	October	November	December	Average for the year
													4 ms.
1871—Average	.....	.....	.....	.....	.....	.....	.....	8,93'	8.99'	8.23'	8.23'	.....	8.60'
Highest	.....	.....	.....	.....	.....	.....	.....	9' 4"	8' 8"	8' 9"	9'	.....	9' 8"
Lowest	.....	.....	.....	.....	.....	.....	.....	8' 8"	7' 11"	7' 7"	7' 8"	.....	7' 7"
												12 31	9 ms.
1872—Average	.....	.....	.....	6.25'	7.80'	8.16'	8.26'	8.19'	8.03'	7.93'	7.58'	7.06'	7.81'
Highest	.....	.....	.....	7' 9"	8' 4"	8' 4"	8' 6"	8' 5"	8' 6"	8' 4"	8'	7' 11"	8' 6"
Lowest	.....	.....	.....	7' 6"	7' 3"	7' 10"	7' 8"	7' 10"	7'	7' 2"	7' 2"	6' 9"	6' 6"
													11 ms
1873—Average	7.24'	7.31'	7.43'	8.13'	8.61'	8.80'	8.88'	8.93'	.....	8.54'	8.53'	8.34'	8.25'
Highest	8' 4"	7' 10"	8' 4"	9'	9' 4"	9' 1"	9' 2"	9' 3"	.....	9' 3"	9' 6"	9' 6"	9' 6"
Lowest	6' 4"	6' 10"	6' 10"	7' 10"	8' 2"	8' 4"	8' 7"	8' 5"	.....	8' 2"	8'	6'	6'
1874—Average	8.55'	8.76'	8.73'	8.66'	8.60'	8.80'	8.93'	9'	8.72'	8.40'	8.14'	7.48'	8.56'
Highest	9' 6"	9' 4"	9' 8"	9' 6"	9'	9' 4"	9' 4"	9' 4"	9' 4"	9'	8' 5"	8' 1"	9' 8"
Lowest	7' 10"	8' 4"	7' 10"	8'	8' 2"	8' 4"	8' 6"	8' 6"	8' 2"	7' 6"	7' 6"	6' 10"	6' 10"
1875—Average	7.41'	7.35'	7.81'	7.98'	8.25'	8.58'	8.68'	8.81'	8.75'	8.55'	8.48'	8.14	8.23'
Highest	7' 8"	8' 4"	8' 8"	8' 6"	9'	8' 10"	9' 2"	9' 6"	10' 4"	9' 6"	9	8' 8"	10' 4"
Lowest	6' 8"	5' 11"	7' 4"	7' 6"	7' 8"	8' 2"	8' 4"	8' 6"	8' 2"	7' 8"	7' 10'	7' 4"	5' 11"
1876—Average	8.29'	9'	8.89'	9.06'	9.41'	10.17'	10.3'	10.28'	10.24'	9.59	9.64'	9.21'	9.51'
Highest	8' 10"	10' 2"	9' 10"	11' 4"	10' 2"	10' 8"	11' 2"	10' 6"	10' 8"	10' 6"	10' 4"	10' 6'	11' 2"
Lowest	7' 4"	7' 10"	8' 2"	8' 6"	8' 10"	9' 6"	10'	9' 10"	9' 6"	8' 2"	9' 4	8'	7' 4"
1877—Average	9.20'	9.20'	9.04'	10.45'	9.40'	9.29'	9.32'	9.18'	8.98'	9	8.97'	8.90'	9.24'
Highest	10' 4"	9' 6"	10' 6"	14'	9' 10"	9' 6"	9' 10"	9' 8"	9' 6"	10'	10'	9	14'
Lowest	8' 10"	8' 4"	8' 4"	9' 2"	8' 10"	8' 8"	8' 10"	8' 8"	8' 6"	8' 6	7' 10"	7' 6	7' 6"
1878—Average	8.84'	8.90'	9.11'	9'	9.03'	9.24'	9.26'	8.87'	8.72'	8.52'	8.70'	8.40	8.88'
Highest	9' 8"	10'	10' 2"	10' 2"	9' 6"	10' 4"	9' 10"	9' 2"	9' 2"	9' 2	9' 2"	9	10' 4"
Lowest	8' 4"	8' 6"	8' 4"	8' 4"	8' 10"	9'	9'	8' 6"	8' 2"	7' 10"	8' 2'	7' 6"	7' 6'
1879—Average	8.5'	8.25'	7.95'	7.88'	8.10'	8.29'	8.32'	8'	8.08'	.....	.....	.....	8.11
Highest	8' 8"	8' 10"	8' 7"	8' 6"	8' 6"	8' 6"	9'	8' 6"	9' 2"	.....	.....	.....	9' 2
Lowest	7' 4"	7' 10"	7' 6"	7' 6"	7' 10"	7' 10"	7' 8"	7' 6"	7' 7"	.....	.....	.....	7' 4

Average for whole time	8.62'
Highest for whole time	14' 00
Lowest for whole time	5.11'

affect the water levels of the Great Lakes. In 1879 the average depth was less than in any year since 1872, and it is just now, probably, lower than at any time during the past fifteen years. The elevation of the lake level is directly and forcibly affected by the force and direction of the wind, the effect produced being frequently as much as three feet. High winds are especially prevalent in the neighborhood of Chicago, and winds blowing with a velocity of forty-five miles per hour, for many hours together, occur. Southwest winds are indeed the prevailing winds in this locality. During last year westerly winds were noted at the Chicago station on one hundred and forty-six days. The driving away of the water from the harbor of Chicago under the action of a southwest wind was sufficient, on one occasion, to lower the water in the canal at Lockport, twenty seven miles away, no less than fifteen inches. Easterly winds operate in a similar manner, in a contrary direction, but easterly winds are not so frequent at Chicago as westerly winds. In 1879 the winds were easterly on ninety-eight days. It is clear that the action of continued westerly winds is to reduce the lake level in the harbor of Chicago, and thus to reduce the volume of water passing into the canal from the river; and it is equally clear that continued easterly winds will operate to raise the lake level, and to increase the flow of water into the canal. The daily fluctuations of the lake level, which are independent of the winds or other accurately defined causes, and which are about nine inches, also affect the flow of water into the canal. Another cause, which has a direct and important bearing on the amount of water flowing into the canal from the river is the water-shed at Chicago, and the rainfall on the country between the Summit and Lockport, which drains into the canal. It will be observed that the natural water-shed at Chicago is into the lake; and when, in the spring, an unusual quantity of water (either of rainfall or melted snow) is to be disposed of, it naturally seeks the lake.* At this time of the year the lake is always low, and the flow of water into the canal is so sluggish that the surface drainage will, of necessity, be into the lake.† The rainfall on the country lying between the Summit and Lockport, which is drained by the canal, is frequently so great in the spring that it raises the water level in the latter to a point that greatly reduces the flow of water from the river into the canal, and sometimes causes the water in the canal to flow backward into the river. In ascertaining the amount of rainfall which will produce these effects, I have had recourse to the reports of the United States signal service, which show the amount of rainfall at Chicago from 1874 to 1879, inclusive.

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*The area of this watershed is at least 250 miles in extent.

†December, 1879.

The following table shows the total rainfall, by months and years:

Year.	1874.	1875.	1876.	1877.	1878.	1879.
January	3.47	0.95	3.22	1.91	1.31	0.54
February	1.51	1.99	3.90	.06	2.12	1.47
March	2.15	1.43	4.04	5.37	4.37	2.37
April	2.63	2.32	2.07	2.42	5.57	1.93
May	2.07	3.64	1.85	6.04	5.22	3.89
June	3.25	5.17	5.96	6.04	3.93	3.18
July	0.58	7.18	3.11	2.98	6.09	5.58
August	3.15	3.29	3.66	3.06	3.66	0.45
September	3.74	4.39	3.74	2.02	6.99	1.18
October	2.52	4.36	1.20	6.51	5.17	2.72
November	2.83	0.74	3.25	6.08	1.83	4.93
December	0.63	2.62	0.48	2.75	2.58	2.47
Total	28.59	38.08	36.48	45.24	48.84	30.71

Fixed and floating ice also affects the amount of water which flows from the river into the canal. When the canal is frozen over, its capacity is diminished in exact proportion to the thickness of the ice, and the flow of water is retarded by the friction against the ice covering it. In severe weather this will vastly diminish the capacity of the canal, considered as a conduit. Floating ice will also retard the current in a marked degree.

FLOW OF WATER THROUGH THE CANAL.

Mr. Thomas, the superintendent of the canal, informs me that he measured the amount of water that passed through the canal at the lock at Bridgeport, the depth being eight and one-half feet, on sixteen consecutive days in the summer of 1873, and found it to amount to 33,000 cubic feet per minute; but, as I have shown in another place, the causes that affect the lake level, the obstruction caused by ice in the winter months, the deposit of sediment, and the sliding in of the banks will greatly reduce the amount of water, and I believe it safe to say that not more than an average of 17,000 cubic feet per minute passed through during the year 1879. In that year the current of the main river was observed on thirty days to flow into the lake, and on ten days no current either way was perceptible. The probabilities are that during the greater part of the winter of 1878-9, when the canal was frozen over, not more than 10,000 cubic feet passed per minute, and perhaps not so much, for at that time of the year the lake level is always the lowest. During the months of June, July and August, when the lake level is the highest, possibly 35,000 cubic feet passed per minute.*

*An observation made by chief engineer Jenne at Chicago, January 28, 1880, gave the following result:

	Feet.	Inches.
Depth of water on floor of lock	7	9
Depth of water in canal	6	10
Flow per minute through canal (cubic feet)	24,000	

Current per hour .9 of a mile.

At this time the canal and river were free from ice.

MR. THORP'S OBSERVATIONS AT JOLIET.

I have given special attention to the conditions existing at Joliet because the first dams are located there, and because the health of that city is apparently endangered by the condition of the river. The dams are in the busiest part of the city, and the water, falling about ten feet, boils and eddies below in such a manner as to facilitate the emission of noxious odors. I am indebted to Mr. Samuel M. Thorp, locktender at this point, for his industry in making and recording daily observations showing the daily stage of water, the odor arising from it, the general force and direction of the winds, the temperature, and the comparative filth and purity of the water.

These observations were begun on October 14, 1877, and continued to the end of November, 1878, and Mr. Thorp has furnished his daily memoranda. From the close of his diary to the present time, general observations have been made in other ways. These papers are too voluminous to be embodied in this report, and I shall attempt only a general analysis of them. During the winter of 1877-8 an increase of sewage and stench was invariably perceived whenever the water at the dam was low, but both disappeared in exact proportion to the increase of water, whether the increase was due to local rains, to causes affecting the water supply of the Des Plaines river, or to the increased quantity of water coming through the canal. The effect of moderate and high winds was to dissipate the odor, and, for many days during Mr. Thorp's observations, no stench was perceived for this reason. Whenever the river was frozen over, the escape of the gaseous emanations and all oxidation above that point being prevented by the ice, the stench was concentrated at and below the dams, where it was liberated by the fall and consequent disturbance of the water. During Mr. Thorp's observations, 249 days are noted in which the water was filthy, and only 14 in which it was clear. On 117 days the odor was marked, on 116 days it was slight, and on 140 days no odor was perceived. On 211 days the water was low, and on 90 days it was high as compared with the low-water mark. It is clearly shown by these observations that a low stage of water was always marked by increased filth, and, unless a high wind was blowing, by an increase in the noxious odor; and that with a slight rise of even an inch or two the water cleared and its stench was less marked. In other words, the less the volume of water the greater the relative volume of sewage. On September 30, 1878, following a low stage of water, the observer noted that the fish were all killed, and on October 15, the stench nauseated passengers on the bridge. It was noticeable also that the days in which the river water was comparatively clean were all in the earlier part of the observations; that is, from October, 1877, to April, 1878, and that later, and especially in the fall of 1878, no days are noted when the water was clean. From the close of Mr. Thorp's observations until February, 1879, when the ice broke up, the odor emanating from the river at Joliet was so universally offensive that public meetings of the citizens were held and committees were appointed to visit Chicago for the purpose of seeking relief, but none could be afforded. With the breaking up of the ice, the odor in a measure disappeared, but the water continued filthy throughout the spring and summer, and the smell was perceptible. With the return of winter

there was a renewal of the nauseous experience of the previous winter, which is explained by the fact that, as appears by the analysis, more than three times as much organic matter was then contained in the water. From that time until the present the water has been filthy without exception, and during this period it is observed that only an unusual rise of water has had the effect of clearing it, though previously the slightest increase had done so in some degree. Again referring to Mr. Thorp's memoranda, I notice that, during the fourteen months which they cover, there was almost continued low water.

Only once did the water rise as high as fifteen inches over the low-water mark, and the average height would not exceed two inches. This indicates that during the period of observation the volume of water which passed over the dam was diminishing, a fact which can be ascribed to the lowering of the lake level at Chicago, thirty-five miles away.

ANALYSIS OF THE WATER.

In 1877, the special investigation of the effect of the passage of the Chicago sewage through the canal and the Illinois river was commenced. On October 12, I went over the canal and the river to Joliet, collecting specimens of water at different points for analysis. The day was cloudy, and there was a slight drizzling rain. These specimens were submitted to Prof. H. A. Weber, chemist at the Industrial University at Champaign, who was directed to make the analysis and to ascertain the amount of organic matter contained in each of them. His report was as follows:

Parts of organic matter found in 1,000,000 parts of water—	PARTS.
No. 1. Specimen from the head of the south fork of the South branch of the Chicago river	539
No. 2. Specimen from the south fork of the Chicago river, near the mouths of two sewers	1,233
No. 3. Specimen from the south fork, at Archer avenue bridge	125
No. 4. Specimen from the South branch, before junction with the West branch and south fork, showing Chicago sewage proper	74
No. 5. Specimen from head of the canal	121
No. 6. Specimen from Lemont, twenty-one miles from Chicago	117
No. 7. Specimen from Guard lock, Joliet	103
No. 8. Specimen from DesPlaines river, one and one-half miles below Joliet	105

Nos. 1 and 2, the latter especially, show the effects of the drainage of the slaughtering and rendering establishments at the stock-yards. No. 3 shows the influence of the lake water passing into the canal. No. 4 shows the condition of the sewage proper of Chicago before its admixture with the refuse of the south fork, as will be seen by No. 5. A slight diminution will be observed in No. 6, showing that but little oxidation had taken place. A more marked effect is observed in No. 7, the water of the Des Plaines river having further diluted the sewage. On October 12, 1877, the water at Bridgeport stood at

eight feet and ten inches. The specimens of water collected by me September 25, 1879, when all these streams were very low, were also analyzed by Prof. Weber, with the following results:

Parts of organic matter in 1,000,000 parts of water—		PARTS.
No. 9.	Specimen from South branch, before junction with West branch and South fork	83
No. 10.	Specimen from head of canal	115
No. 11.	Specimen from Guard lock, Joliet	102
No. 12.	Specimen from Morris	100
No. 13.	Specimen from DuPage river	45
No. 14.	Specimen from Illinois river at Henry	55
No. 15.	Specimen from Illinois river, two miles above Peoria	58
No. 16.	Specimen from inlet pipe of Peoria water works	83
No. 17.	Specimen from water supply at Peoria, through water works	54

I regret that the specimens from LaSalle and Ottawa were unfortunately lost in transit. For purposes of comparison, I call attention to specimens collected at other times. Numbers 18, 19 and 20 were collected on October 20, 1879:

Parts of organic matter in 1,000,000 parts of water—		PARTS.
No. 18.	Specimen from Sangamon river, above Riverton	41
No. 19.	Specimen from Sangamon river below paper mill and distillery	126
No. 20.	Specimen from Sangamon river, office of Board of Health, in the State House	73
No. 21.	*Specimen from Mississippi river, at Cairo	24
No. 22.	*Specimen from Ohio river	32
No. 23.	*Specimen from cistern at Cairo (filtered)	33
No. 24.	*Specimen from cistern at Cairo (not filtered)	95
No. 25.	*Specimen from drive-well at Cairo	105
No. 26.	*Specimens from two cisterns at Cairo	116
No. 27.	†Specimen from experimental well, near Springfield water works	24
No. 28.	†Specimen from inlet pipe, Sangamon river	85
No. 29.	†Specimen from office of Board of Health, State House	54
No. 30.	‡Specimen from head of canal, Chicago	309
No. 31.	‡Specimen from Des Plaines river, at Joliet	364
No. 32.	‡Specimen from Illinois river, at Morris	209
No. 33.	‡Specimen from Fox river, at Ottawa	100
No. 34.	‡Specimen from Illinois river, above mouth of Fox	181

* Collected September 20, 1878.

† Collected December 1, 1879.

‡ Collected December 23-24, 1879.

Distances on Canal and River to Chicago—

Bridgeport	0	Joliet	33	LaSalle	96
Summit	8	Channahon	44	Hennepin	112
Willow Springs	14	Morris	57	Henry	124
Sag	17	Seneca	69	Lacon	131
Lemont	21	Ottawa	81	Chillicothe	139
Lockport	29	Utica	91	Peoria	159

The DuPage river unites with the Des Plaines river at Channahon, forming the Illinois, and 47 miles from Bridgeport the Kankakee empties into it, and at Ottawa the Fox.

The specimens collected at Peoria did not reach Prof. Weber in time for analysis. These specimens for comparison must necessarily be only approximate, as the organic pollution is not always equally distributed. They only indicate, in a general way, the condition of the water.

The difference between the specimens collected on December 23 and 24, at the head of the canal, and those from the Des Plaines river at Joliet, is thus accounted for: The water being comparatively stagnant at the head of the canal, some of the solids would doubtless be precipitated, while the passage of the water through the mill-way at Lockport, and over the two dams at Joliet, would thoroughly mix them. The difference between the specimens collected on September 25, 1879, and on December 24, 1879, is very great, and can be accounted for by the fact that on September 25, 1879, Mr. Jenne, the engineer of the canal, estimates that about 20,000 cubic feet passed each minute; and on December 23 and 24, 1879, only about 10,000 cubic feet passed per minute.

There is no doubt that practically no change takes place, or very little, between Chicago and Joliet when the canal is frozen over, oxidation being to a great extent suspended. Generally speaking, I was disappointed at the small amount of oxidation that occurred when the river was free from ice. The change between Joliet and Morris is no doubt due to the increase of water in the river and to oxidation. These causes also affect the water at Ottawa. I am somewhat surprised at the amount of organic matter found in the Fox river. It may, however, be due to the fact that the water of streams that are frozen contains more organic matter than when they are not. This large amount of organic matter explains the fearful stench at Joliet and other points below on the river. The odor is peculiar, and could be detected as far down as LaSalle during the last winter. It was also said that it was perceived at Peoria, but of this I have no positive evidence, as their local conditions might have caused the pollution of the water. I hope, however, soon to be able to settle the question definitely.* I am satisfied that the sewage that is carried through the canal at this time comes mainly from the South fork, as I detected its peculiar odor at Joliet on two occasions recently. During the winter months, the slaughter-houses are using a great amount of water in carrying on their business, which necessarily drains into the South fork. This fact inclines me also to believe that the greater part of the sewage in those months comes from the South fork, whenever there is a low lake level. More slaughtering is done in the winter months, and there is more human excreta than in summer, and it is always at this time that the sewage is the least diluted.

* Analyses of specimens collected January 5, 1880, enable me now to say that the effect of Chicago sewage on the waters of the Illinois river is distinctly perceptible at Peoria when the canal and river are frozen over. The results of these analyses are as follows:

Parts of organic matter in 1,000,000 parts of water—	PARTS.
Specimen from river at ferry	121.54
Specimen from water works (after being pumped)	116.65
Specimen of Peoria well water	31.60

The loss of impurity after passing through the water works is probably due to the aeration in pumping and consequent oxidation. These specimens were collected just before a heavy rain and thaw, under which the ice in the canal and river broke up and surface drainage into the canal was restored.

GENERAL OBSERVATIONS.

From a careful consideration of all these facts, I conclude that a practical and immediate remedy for the present pollution of the Chicago river can only be found in a greater and more constant flow of water from the lake into the canal, and that the pollution of the Illinois river depends mainly upon the stage of water. The variability of the flow from the lake into the canal and the Illinois river is a well ascertained fact, and it is equally well ascertained that the average flow which was formerly sufficient to dilute the sewage, and facilitate its oxidation, is not sufficient now. These considerations indicate with certainty the remedy for all the pollution complained of. It will be found in increasing the flow of lake water through the canal, and in rendering such flow constant, instead of variable. In this connection, I call attention to the following:

Extract from forthcoming report of William Thomas, General Superintendent of the Board of Canal Commissioners of Illinois, for 1879:

In conclusion, I wish to call your attention to the consideration of the condition of the Summit level, or "deep cut," as it is sometimes called. When the water was let into this level the lake was three feet and over higher than it is now, or has been most of the fall months, making that much less water in the canal. Navigation has been badly interfered with on this account. Either the whole length of bottom must be lowered, or its water at Bridgeport must be raised. In my judgment, it was a great mistake that the old hydraulic works and lock at Bridgeport had not been preserved, for, with those works, it is well known that the water could be raised at that place to any height desired, and at a very trifling expense, compared to the magnitude of the work and its worth to the city of Chicago. With those works restored and the canal in its present condition, with an expense not to exceed $75 per day, all the water in the South branch could be kept nearly as clean as the lake itself, the navigation of the Summit level be made good, and all complaints about stink done away with. Little or no dredging would be needed, as the high stage of water in the canal would prevent the bank from sliding in. It seems to me that the city of Chicago, and your Board, should take steps immediately to inquire into this subject. The question of raising the water there by steam and cleansing the river is no new one; nor is it an experiment, as many well know it has been successfully done. The circumstances are much more favorable now than heretofore. Then, there was a difference of eight feet between the surface of the water in the canal and river, at Bridgeport. Now, the difference would be whatever you should make it. Then, there was no declivity in the canal from Bridgeport to Lockport; now, there is a fall of three feet. Then, the surface of the water in the canal, most of the way, was as high as the surface of the earth along its banks, and much of the distance higher, and any raising of the water produced an overflow. Now, the surface of the water in the canal is from eight to ten feet below.

A PRACTICAL REMEDY SUGGESTED.

I have given Mr. Thomas' recommendation much thoughtful consideration, and have paid especial attention to the history of the efforts to cleanse the Chicago river by pumping, previous to the opening of the "deep cut," which I have already detailed. I remark, in this connection, that the proper sewage of the city of Chicago and of the south fork of the river is at times shut off from passing into the canal by the rush of water out of the West branch. The potency of the fact will be recognized when it is remembered that it was found necessary to dam the Ogden ditch to prevent the flow of water from the Des Plaines river into the canal, and that the West branch drains the territory from about five miles north and about eight miles east toward its mouth. The conclusion I have reached is, that the re-establishment of pumping works at Bridgeport will accomplish the cleansing of the Chicago river at all stages of the lake level and under all the known conditions imposed by unfavorable winds, rain-fall and tidal waves, excepting unusual freshets, such as have occurred twice within the last ten years, and that this plan will also furnish a sufficient supply of water in the canal and Illinois river to so far dilute the sewage and facilitate its oxidation as to render it innoxious and odorless at all the points where it is now recognized as a nuisance.

I conclude, also, that this is the only plan which can be adopted with sufficient promptitude to accomplish the desired end at an early day. The sanitary necessity is so pressing that no time should be lost. I therefore suggest that the Board recommend to the city of Chicago the re-establishment of these works with the least possible delay. In making this recommendation the Board is simply performing a duty imposed upon it by section 2 of the act creating it, of which the following is an extract:

"The State Board of Health shall have the general supervision of the interests of the health and lives of the citizens of the State."

This will be the first time that the Board has made a recommendation to the city of Chicago in relation to its sanitary affairs. There is another view of the case to which the attention of the municipal authorities of Chicago should be called, which is, that that city has no right to unnecessarily injure the material and sanitary interests of any other part of the State. The community of interests which exists between the citizens of Chicago and the inhabitants of the country lying along the canal and river, forbids the injury of either by the other. It is but just to state that the plans heretofore adopted for the sewerage and drainage of the city of Chicago have been made with a view to such change as the future might require. The deepening of the canal, which was begun in 1865, was not completed until 1871, so that the relief afforded by that measure was delayed six years from the time when its necessity was recognized. The pumping-works can be rebuilt in ninety days. My reasons for recommending this course are that the works will furnish almost immediate relief without great expense, and without interfering with the project of a ship canal, or with any more permanent plan which may become necessary for disposing of the Chicago sewage. The oxidation of organic matter is promoted by the process of pumping, as will be seen by comparing the analysis of specimens Nos. 16 and 17. No. 16 was taken from

the mouth of the inlet pipe at the Peoria water works, and contained 83 parts of organic matter in a million parts of water, while No. 17, which was taken on the same day, several hours later, after the water had passed through the works, contained only 54 parts. Specimen No. 19, taken from the Sangamon river, below the paper mill and distillery, and several miles above the Springfield water works, contained 126 parts, while specimen No. 20, taken from the office of the Board, at the State House, contained but 73 parts. Specimen No. 28, taken from the inlet pipe of the Springfield water works, on December 1, contained 86 parts, while No. 29, taken from the office of the Board, contained but 54 parts.

The agency of the pumps in promoting oxidation will be more needed in winter than in summer, because, among other things, in summer the stirring of the water in the canal by the passage of boats promotes oxidation in some degree at least, but, more importantly, because low temperatures retard oxidation. I remark that any other plan that will afford relief will involve a much larger expense than this will, and much longer time to effect the result. The cost of the pumping works, which were erected by the State in 1859 and 1860 to supply the canal with water for purposes of navigation, was $42,158.24. From the statement of their operation contained in the reports of the Canal Commissioners, I have computed that they raised about ten thousand cubic feet of water per minute eight feet high. The building yet remains, though it is leased to private parties for a short time. I have no doubt that an arrangement could be made with the Canal Commissioners for its use without any expense to the city of Chicago. I am informed that the old lock can be restored at a cost of not more than $10,000. If the whole expense of re-erecting the works should be $60,000 or $70,000, and the expense of operating them should amount to $100 per day, it would be trifling compared to the benefits which would result. I am satisfied that an equitable arrangement can be made with the Canal Commissioners for maintaining the work. The fall from the head of the canal to Lockport, a distance of twenty-nine miles, is three feet, and the current between those points has a velocity of half a mile per hour at this time. The velocity will increase in proportion as the water at the head of the canal is raised, and the increase will promote the oxidation of sewage. After a careful investigation, I am satisfied that, with fifty thousand cubic feet of water passing into the head of the canal per minute, the main river and the South branch will be purified; that no nuisance will result from sewage at Joliet and below, and that the potability of the water in the Illinois river at Peoria will not be in the least affected from that source. An increase of water to sixty thousand cubic feet per minute would, in my opinion, take in addition the sewage of the North branch after it has once been cleaned out, and would diminish the nuisance in the South fork of the South branch at least three-fourths.

I am informed by practical men that the increase of current in the canal, which would result from this increase of water, would not materially interfere with navigation, because of its increased depth. The lake level is lower now than it has been for a number of years, but, judging by the experience of the past, it will begin

to rise within a year, and will continue to rise during a number of years. But no improvement in the condition of the water in the canal and river can be expected from this cause, for the increased flow into the canal which the higher lake level will produce, will not keep pace with the increased sewage.

The Fullerton avenue conduit is now completed, and an experimental test will soon be made. I do not share in the great apprehension that exists in the minds of many with regard to the effect upon the pollution of the water supply of the city of Chicago, if the water is pumped from the North branch into the lake, at present, but I think probable that, under certain conditions, it may pollute it.* Pumping water from the North branch into this conduit will necessarily cause a flow of water from the main river into the North branch. How far this will affect the flow of water into the South branch from the main river under existing circumstances, I am not prepared to say, but I do not hesitate to say that at the time when the current is toward the lake, it will be almost impossible to purify the North branch in this way, for the sewage of both the main river and the South branch will flow into it. The water in the North branch, north of the conduit, is much less foul than that further south, and it is with special reference to the purification of the latter that the conduit was constructed. But under certain conditions it will happen that the effect of pumping will be to draw off the comparatively clean water at the north end of the branch without materially affecting the fouler water below, as when there is a considerable supply of water by rainfall draining into the branch, which does not amount to a freshet, changes in the lake level from any cause may also produce this effect. Of course, when there is a freshet out of the North branch, the operation of the pumps is not needed for its purification. At times, when the water is pumped from the lake into the North branch, its effect will be to create a current into the main river, and thence through the South branch into the canal, diminishing, or at times cutting off the supply of water which otherwise flows from the lake into these channels. This will add the sewage of the North branch to the South branch.

I have already shown that the current into the head of the canal, under the most favorable circumstances, barely keeps the main river and the South branch in a tolerable condition. The addition of the sewage of the North branch to the South branch would render the lower portions of the latter nearly as foul as the North branch now is. In other words, it would only amount to a transfer of the nuisance, and an increase of the nuisance at Joliet, and the pollution of the Illinois river. At other times, the effect of pumping water from the lake into the North branch, will be to carry the sewage from the latter into the lake through the main river, and when the current is sluggish to cause the latter and, to some extent, the South branch, to become foul and offensive. Either way, the sewage will at times find its way to the lake. If

* Since the Fullerton avenue conduit has been pumping from the North branch to Lake Michigan, complaint has been made several times that the water supply of Lake View had been polluted by it.

it is desirable or necessary to prevent this, it can be done by increasing its flow of water from the lake into the canal, and it can be done in no other way.

It is better for the city of Chicago that all the sewage should pass into the canal, but it should be so diluted as to prevent injury to the sanitary condition of the country below. If 60,000 cubic feet of water per minute at the head of the canal will not create the necessary current to effect this purpose, I have only to remark that the amount may be increased up to 100,000 cubic feet, which, according to Mr. Thomas, is the present capacity of the canal. Ever since 1872, the south fork of the South branch has been a standing menace to the health of the city of Chicago. Frequently, when foul odors are blown across the city, characterized by a peculiar sickening, deadening stench, and attributed to the slaughtering, rendering, and fertilizing establishments, it really comes from this source. For the purification of this, which is one of the foulest bodies of water within my knowledge, various plans have been proposed: among others, the construction of a large sewer and pumping works, for conveying the water either into the lake or the canal. The condition of this water will be appreciated better than any words can possibly describe it by reference to the analysis of specimen No. 1, from the head of the south fork, which contained 539 parts of organic matter in a million, and specimen No. 2, from near the mouths of two sewers, which contained 1,233 parts, while specimen No. 4, from the South branch, before its junction with the West branch and South fork, contained only 74. From the location of the old pumping works, on the same side and near the mouth of the South fork, I am satisfied that the pumping works will, to a great degree, purify this water. Specimen No. 3 was taken from this fork at the Archer avenue bridge, some distance from its mouth, and contained only 125 parts, showing the purifying effect of the lake water passing through the South branch to the canal.*

All of which is respectfully submitted.

JOHN H. RAUCH, M.D.

NOTE.—By direction of the Board a copy of the above report was submitted to the Mayor and Common Council of the city of Chicago, on January 12, 1880, and in order to carry out the recommendations therein contained, an appropriation of $100,000 was made by the Common Council for the purpose of constructing pumping works at the head of the canal. While the matter was pending before the

*Specimens of water collected February 10, 1880:

	Organic matter in 1,000,000 parts.
No. 1. Chicago river midway between Dearborn and State streets	28
No. 2. South branch, 200 yards from head of canal	132
No. 3. Canal 200 yards from head	268

It will be observed that on this day about one-half of the organic matter came from the South fork. The water in the canal was seven feet and seven inches in depth, and there was a slight current from the lake. For the two preceding days the water was six inches lower, and there was a slight current towards the lake from Twelfth street, while from there to within 400 yards of the head of the canal the water was practically stagnant, the South fork, and the West branch supplying nearly all the water which the canal carried away, which was about 1,800 cubic feet per minute. During the remainder of the month the current from Halstead street was toward the lake, with the exception of the three last days. From these facts it will be seen how easily the current in the Chicago river is changed, at the same time affecting the amount of the pollution in the canal.

Council, the subject was widely discussed by the press, the Chicago Citizens' Association and the Engineers' Club, conferences were held between the State and City authorities, and an important convention was held at Ottawa looking to pushing the construction of the ship canal from Lake Michigan to the Illinois river. While this last would undoubtedly afford an adequate and permanent method of disposing of the sewage of Chicago, (provided, that such canal be made wide and deep enough to properly dilute the sewage,) and while possibly some of the numerous other plans which have been since suggested would achieve the result sought for, I see no reason for modifying my conclusion above given, namely, "that this resort to pumping is the only plan which can be adopted with sufficient promptitude to accomplish the desired end at an early day." It is immaterial whether this pumping be done from the south fork through a canal connection via the stock yards, or by works located at the Ogden ditch and emptying into the Des Plaines river; or, as is specifically suggested, by re-establishing the pumps at Bridgeport. If this last be done so as to secure a capacity of 60,000 cubic feet per minute when desired, the facts and figures cited in the report demonstrate that substantial relief will be secured for some time to come. With the growth of the city and consequent increased production of domestic and manufacturing wastes and refuse, the time will arrive when 60,000 cubic feet per minute will not dilute the sewage to the point of inoffensiveness, but when that time arrives, additional works may be constructed at Ogden ditch with a capacity of say 150,000 cubic feet, and with these two systems the sewage of a population of a million and a half may be satisfactorily disposed of. The vital point now is speedy relief from a grave sanitary danger; one which not only affects Chicago, but which either threatens to, or actually does, pollute the water supply of neighboring communities; which seriously menances the health of the river towns, and poisons the atmosphere many miles south of the source of the evil. Does not Chicago owe it to herself and to her neighbors to act promptly and efficiently in the matter? Can she afford to invite not only epidemic diseases and increased death-rate? Can she afford to still further incur the risk of pollution of her own water supply and that of her neighbors on the lake? From the data presented in the foregoing pages it seems obvious that only one available remedy exists for these imminent evils, namely, the removal of her sewage, properly diluted, by the water courses flowing towards the Mississippi river.